Outcomes of Carotid Endarterectomy with Primary Closure

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Abstract

Carotid endarterectomy (CEA) reduces the risk of stroke in patients with internal carotid artery stenosis, although the optimal surgical technique is debated. The literature suggests that patch angioplasty reduces complication risk, although primary closure shortens cross-clamp time and eliminates complications associated with grafts.

The objective of this study was to assess the complication rate after CEA with primary closure.

Retrospective review of 240 consecutive patients between 2002 and 2010. Of these patients, 70% returned for follow-up visits for at least 2 or more years.

Primary closure was used in all patients. The average cross-clamp time was 18 minutes. Complications in the immediate postoperative period within 30 days were as follows: stroke ($n = 3$; 1.1%), transient ischemic attack (TIA; $n = 4$; 1.5%), myocardial infarction (MI; $n = 3$; 1.1%), and death ($n = 1$; 0.4%). Short-term follow-up revealed eight patients who were found to have significant restenosis ($>80\%$) by carotid duplex imaging. Two to ten year postoperative complication rates were as follows: stroke ($n = 7$; 4.2%), TIA ($n = 7$; 4.2%), amaurosis fugax ($n = 1$; 0.6%), MI ($n = 8$; 4.8%), and death ($n = 28$; 17%). Mortality was due to stroke or heart attack ($n = 2$; 1.2%), cancer ($n = 7$; 4.2%), and unknown causes ($n = 19$; 11%).

This study presents our experience with complications after primary closure after CEA. In our experience, CEA is a safe and effective surgical means of preventing stroke in the short term. Well-designed prospective studies are needed to confirm specific patient characteristics in which primary closure and patch angioplasty are indicated.

Keywords

- atherosclerosis
- carotid endarterectomy
- carotid stenosis
- stroke
- vessel repair
- patch closure
- primary closure
- carotid endarterectomy outcomes

Background

Carotid endarterectomy (CEA) is a proven surgical means of reducing the risk of stroke in both symptomatic and asymptomatic patients with internal carotid artery stenosis. However, different surgical techniques may affect the short-term

outcomes. Despite the efficacy and popularity of CEA, considerable debate still exists regarding the ideal method of arteriotomy closure. Many surgeons have advocated patch angioplasty as a means of reducing the incidence of acute internal carotid artery thrombosis in the short term by increasing lumen size, thereby reducing the risk of perioperative stroke.^{1–8} In the long

term, some authors have advocated for the use of patch angioplasty due to the theoretical advantages of patch closure in reducing the rate of recurrent atherosclerotic carotid artery stenosis.²⁻⁶ Possible disadvantages of patch closure are longer carotid cross-clamping time and possible morbidity associated with vein harvesting, including hemorrhage and infection.⁹⁻¹¹ Patch angioplasty has also been associated with rare complications such as patch rupture and false aneurysm formation.¹² Using the saphenous vein as opposed to synthetic materials as a patch has been noted to cause more patch rupture.¹³⁻¹⁵ CEA with primary closure and proper medical management may be equally effective at preventing recurrent stenosis and has the advantage of reduced operative time.¹² In a previous study of this surgeon's cases, perioperative and short-term outcomes within 30 days and up to 2 years were assessed, with results showing that CEA with primary closure is a safe and effective surgical means of preventing stroke.¹⁶ Thus, we sought to further assess the outcomes of CEA with primary closure by retrospectively reviewing the charts of 240 consecutive patients and analyzing the incidences of restenosis, stroke, myocardial infarction (MI), transient ischemic attack (TIA), amaurosis fugax (AF), and death.

Methods

This study was a retrospective analysis of the short-term results of patients who underwent CEA with primary closure between the years 2002 and 2010.

Operative Technique

Operations were performed under general anesthesia. Patients received 5,000 units of heparin intravenously before cross-clamping of the internal carotid artery. Induced hypertension to a systolic pressure more than 160 mm Hg or at least 25% more than baseline level was used in all patients. The artery was then occluded, and incision was made. Endarterectomy was performed with Penfield dissector, sharply divided in the common carotid, eversion technique performed on the external carotid, and direct feathering technique for the internal carotid artery. The endarterectomy was completed, and the wound was closed primarily with 6-0 running Prolene (Ethicon, Sommerville, NJ) sutures. Intraoperative duplex was performed to ensure adequate flow. Heparin was not reversed. Patients were monitored intraoperatively with electroencephalography (EEG). Patients received selective shunting if EEG changes were noted; these patients were excluded from analysis. Intraoperative duplex examination was performed. Postoperatively, patients were hospitalized in the intensive care unit overnight, where they received a low dose of low molecular weight dextran (an antithrombotic agent that reduces platelet aggregation) and a nicardipine drip for blood pressure control.

Follow-Up

Patients were followed up in the clinic every 6 months on average. Carotid duplex was performed with every follow-up visit on all patients. Follow-up was supplemented with telephone interview and the completion of a structured questionnaire. Information regarding deceased patients

was obtained from family members and/or Social Security Death Index. The length of follow-up ranged between 2 to 10 years, with the average being 5 years.

Results

Demographics and Clinical Features

Included in this study were 240 consecutive patients who underwent 268 surgeries between 2002 and 2010. Of these patients, 167 (70%) returned for follow-up visits for at least two or more years. Seventy-three (30.4%) of our original 240 patients were lost to follow-up. Thus, for the evaluation of short-term outcomes, we analyzed the records of 167 patients who underwent 185 surgeries. Eighteen patients underwent bilateral procedures. The study population consisted of 56% men and 44% women. The average age was 68 years, and the age range was 33 to 85 years. Many patients had comorbidities including tobacco abuse (69%), coronary artery disease (58%), hypertension (87%), diabetes mellitus (35%), and hyperlipidemia (64%). Patients presented with the following symptoms: 17% of patients had a history of stroke, 52% had TIA, and 10% had amaurosis fugax. Thirty-nine percent were asymptomatic.

Of the 268 surgeries performed, 11 were noted to have complications during the 30-day postoperative period, including stroke, TIA, MI, and death. There were three incidences of thromboembolic stroke (1.1%), four of TIAs (1.5%), three of MIs (1.1%), and one of death (0.4%) (► Table 1). Of the patients who suffered from thromboembolic stroke, two (0.7%) had CEA for symptomatic carotid stenosis, whereas one (0.4%) had CEA for asymptomatic carotid stenosis. The one patient who died during the 30-day postoperative period had undergone CEA for symptomatic carotid stenosis; the patient expired after discharge due to atrial fibrillation (AF).

Table 1 Early postoperative events (30 days)

Postoperative event	No. of cases/incidence
Overall Stroke	3 (1.1%)
Stroke in symptomatic CS ^a	2 (0.7%)
Stroke in asymptomatic CS ^a	1 (0.4%)
TIA	4 (1.5%)
MI	3 (1.1%)
Overall death	1 (0.4%)
Death in symptomatic CS ^a	1 (0.4%)
Death in asymptomatic CS ^a	0 (0%)
Overall stroke and death	1.5%
Stroke and death in symptomatic CS ^a	1.1%
Stroke and death in asymptomatic CS ^a	0.4%

Abbreviations: CS, carotid stenosis; MI, myocardial infarction; TIA, transient ischemic attack.
^aStroke, death, and combined stroke and death rates separated for carotid endarterectomy performed on symptomatic and asymptomatic carotid stenosis.

Fig. 1 The Kaplan–Meier curve for reinterventions.

Thus, the combined stroke and death rate was 1.5% during the immediate postoperative period. The stroke and death rate separated for patients who had CEA performed for symptomatic and asymptomatic carotid stenosis were 1.1 and 0.4%, respectively.

During the short-term follow-up period, eight (4.8%) patients were found to have significant restenosis (>80%) by carotid duplex imaging. Of these eight, half needed reintervention with stent (2) or patch (1); one patient reported undergoing reintervention at an outside hospital but was not able to specify what type of procedure was performed. Two to ten year postoperative complication rates are as follows: thromboembolic stroke ($n = 7$; 4.2%); TIA ($n = 7$; 4.2%); amaurosis fugax ($n = 1$; 0.6%), MI ($n = 8$; 4.8%), and death ($n = 28$; 17%). Of these deaths, 2 were due to stroke or heart attack (1.2%), 7 were due to other causes such as cancer (4.2%), and in 19 patients, causes of death were unknown (11%) (►Fig. 1; ►Table 2). Perioperative TIA rates are as reported in the previous section (early 30-day results).

Table 2 Late follow-up events

Postoperative event	No. of cases/incidence
Restenosis (>80%)	8 (4.8%)
Reintervention	2 (stent), 1 (patch), 1 (unknown)
Stroke	7 (4.2%)
TIA	7 (4.2%)
Amaurosis fugax	1 (0.6%)
MI	8 (4.8%)
Death	28 (17%)

Abbreviations: MI, myocardial infarction; TIA, transient ischemic attack.

A discussion of antiplatelet use is also of interest, as there is no consensus on the use of dual antiplatelet therapy. Most patients were placed on either aspirin (20; 10.8%) or plavix (29; 15.7%), or both (129; 69.7%). A small number of patients (7; 3.78%) received no antiplatelet therapy. Of the patients who received aspirin-only therapy, there were two (10%) cases of significant ipsilateral restenosis, one (5%) of restenosis requiring reintervention, and three (15%) of death. Of those patients receiving plavix-only therapy, there were three (10.3%) cases of deaths, three (10.3%) of significant ipsilateral restenosis, and two (6.90%) of stroke. Of those receiving no antiplatelet therapy, there was one (14.3%) incidence of TIA, one (14.3%) of MI, and one (14.3%) of significant ipsilateral restenosis. Of those receiving dual antiplatelet therapy, there were 2 (1.55%) cases of significant ipsilateral restenosis, 3 (2.33%) of reintervention, 5 (3.89%) of stroke, 7 (5.43%) of MI, 86 (4.65%) of TIA, 1 (0.77%) of AF, and 22 (17.1%) of death (►Table 3).

Women accounted for 41% of the study population. Compared with men, there was a 4.29 versus 5.15% chance of significant restenosis, 2.86 versus 2.06% requiring reintervention, 5.71 versus 3.09% chance of stroke, 4.29 versus 5.15% chance of MI, 8.57 versus 1.03% chance of TIA, 1.43 versus 0% chance of AF, and 12.9 versus 19.6% chance of mortality rate (►Table 4).

Discussion

Many studies have demonstrated the efficacy of CEA as a means of stroke prevention^{17–19}; however, much debate remains regarding whether patch angioplasty or primary closure is the most beneficial technique in achieving lower incidences of postoperative restenosis and other complications such as stroke, TIA, MI, and death. Some surgeons have advocated patch angioplasty as a means of reducing the

Table 3 Antiplatelet therapy and postoperative events

Antiplatelet therapy	No. of patients	Sig restenosis	Reintervention	Stroke	MI	TIA	AF	Mortality
Aspirin only	20 (10.8%)	2 (10%)	1 (5%)	0	0	0	0	3 (15%)
Plavix only	29 (15.7%)	3 (10.3%)	0	2 (6.9%)	0	0	0	3 (10.3%)
Dual	129 (69.7%)	2 (1.55%)	3 (2.33%)	5 (3.89%)	7 (5.43%)	6 (4.65%)	1 (0.77%)	22 (17.1%)
Neither	7 (3.78%)	1 (14.3%)	0	0	1 (14.3%)	1 (14.3%)	0	0

Abbreviations: AF, amaurosis fugax; MI, myocardial infarction; TIA, transient ischemic attack.

Table 4 Gender and postoperative events

	Gender	Significant restenosis	Reintervention	Stroke	MI	TIA	AF	Mortality
Female	70 (41.9%)	3 (4.29%)	2 (2.86%)	4 (5.71%)	3 (4.29%)	6 (8.57%)	1 (1.43%)	9 (12.9%)
Male	97 (58.1%)	5 (5.15%)	2 (2.06%)	3 (3.09%)	5 (5.15%)	1 (1.03%)	0 (0%)	19 (19.6%)

Abbreviations: AF, amaurosis fugax; MI, myocardial infarction; TIA, transient ischemic attack.

incidence of acute thrombosis in the short term by increasing lumen size, thereby reducing the risk of perioperative stroke.^{1–6} However, disadvantages of patch closure are prolonged carotid cross-clamping time and possible morbidity associated with vein harvesting, including hemorrhage and infection.^{3,20,21}

In a study of 917 cases examined by Hertz et al,¹⁸ three false aneurysms developed and required repair in the patched cases, and none developed in the unpatched group. In a series of Awad and Little,¹⁹ the time required for cross-clamping in CEA with patch angioplasty was 15 minutes longer than in the group with primary closure. Increased cross-clamp time may increase the risk of perioperative neurologic complications.

Recurrent stenosis for CEA has been documented in the literature to occur at varying rates. A study by Clagett showed

an increase in restenosis with use of patch closure (12.9 vs. 1.7%) in a mean period of 22 months.¹⁷ In a study by Gelabert et al,²⁰ there was a reported 4.3 to 6.5% incidence of late stenosis in patients undergoing CEA with primary closure. Comparably, in a previous study of this surgeon's cases, 2-year follow-up of patients undergoing CEA with primary closure yielded only 1.3% incidence of restenosis requiring revision. In our current study, we reviewed patients' immediate outcomes within the first 30 days as well as outcomes from 2 to 10 years, and found similarly that only four patients had significant restenosis (4.8%), with only half (2.4%) required reintervention in the follow-up period. Thus, our rates of restenosis and reintervention are consistent with or lower than other studies on CEA with primary closure as well as those using patch angioplasty (→Fig. 2).

Fig. 2 The Kaplan–Meier curve for strokes.

Fig. 3 The Kaplan–Meier curve for mortality.

In conclusion, CEA with primary closure results are comparable to previously published CEA with vein patch closure results. We have shown low rates of restenosis (4.8%), and our risks in terms of perioperative morbidity and mortality are quite low. Furthermore, long-term risk of stroke is low after CEA with primary closure (4.2%) (**Fig. 3**).

Patch angioplasty may not be a better means of closure for most patients undergoing CEA. In certain populations, such as patients with small-diameter vessels, and particularly women, patch closure may be beneficial.²² In fact, a 2009 Cochrane review of randomized and quasirandomized trials involving nearly 2,000 patients comparing patch angioplasty versus primary closure demonstrated that patch angioplasty was associated with a reduction in the risk of ipsilateral stroke during the perioperative period and long-term follow-up and a reduced risk of restenosis during long-term follow-up, although these results were limited by the small sample sizes and significant loss to follow-up.⁹ Furthermore, the Cochrane meta-analysis reported that primary closure was associated with a threefold excess risk of early postoperative stroke or carotid thrombosis and more than 50% restenosis; however, the studies had low statistical power.²³ However, we have been able to use primary closure and selective shunting based on EEG changes in our patient population for satisfactory results. While the evidence presented in this study does not lend proof to change in general practice patterns, our data contribute to the existing literature on CEA with primary closure with more extended follow-up than most other previously published studies.

Our study has several limitations. It was a single-center study, and follow-up was only 70% at 2 years, thereby limiting the generalizability of the results. Our retrospective study results are comparable to those in the literature; however, a superior study design would be to directly compare patch with primary closure with outcomes of complications and rates of reintervention. A comparison of

symptomatic versus asymptomatic patients, and a correlation with the timing from presentation to intervention, is also a crucial element for future study design. It would also be of interest to know the diameters of the carotid artery on preoperative imaging, as the smaller carotid diameter in women may be a reason that some preferentially use patch closure. Nonetheless, our study contributes data on CEA with primary closure with more extended follow-up (up to 10 years) than most other previously published studies.

Conclusions

This study presents our experience with complications after primary closure after CEA. Primary closure has the advantage of reducing cross-clamp times and eliminating graft-specific complications when compared with patch angioplasty. Large studies have supported excellent results when primary closure has been used. Well-designed prospective studies are needed to confirm the specific patient characteristics in which primary closure and patch angioplasty should be indicated.

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Conflict of Interest

The authors have no conflicts of interest to report.

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